

NOTES ON THE CHALCID PARASITES OF MUSCOID FLIES IN AUSTRALIA.

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(Text-figures 1-7).

On account of the economic importance of Muscoid flies, since they include not only the house fly or typhoid fly but also most of the various sheep maggot flies or blow-flies as well as the common "bush flies" of Australia, considerable attention has been given to the study of their hymenopterous parasites, at least one of which has been utilised in New South Wales and Queensland as an agent to assist in controlling the spread of these Diptera. It has also been suggested to the Federal authorities by an eminent British entomologist that a number of species might, with advantage, be introduced from England to assist in this work.

Mr. W. W. Froggatt has done a considerable amount of work on fly parasites, having dealt with no less than three, viz., *Nasonia brevicornis*, *Chalcis calliphoræ* and *Dirrhinus sarcophagæ*, which destroy pupæ of one or more of the sheep maggot flies.

In this paper we propose (1) to give our own observations on two species, one of which is now recorded for the first time as occurring in Australia; (2) to briefly review the work on the parasites recorded as being already present in the continent; and (3) to discuss the suggestion that certain other wasps might be profitably introduced.

The following five muscid-destroying chalcids are now known to occur in Eastern Australia: (1) *Spalangia muscid-arum*; (2) *Nasonia brevicornis*; (3) *Chalcis calliphoræ*; (4) *Dirrhinus sarcophagæ*; (5) *Pachycrepoides dubius*. The first, second and fifth belong to the Pteromalidæ and to the subfamilies Spalangiinæ, Pteromalinæ, and Sphegigasterinæ.

respectively : while the others are members of the Chalcididæ. The first, second and fifth are known from Queensland, the second, third, fourth, and perhaps also the first, from New South Wales.

(1) *Spalangia muscidarum* Richardson

(Text-figures 1-7).

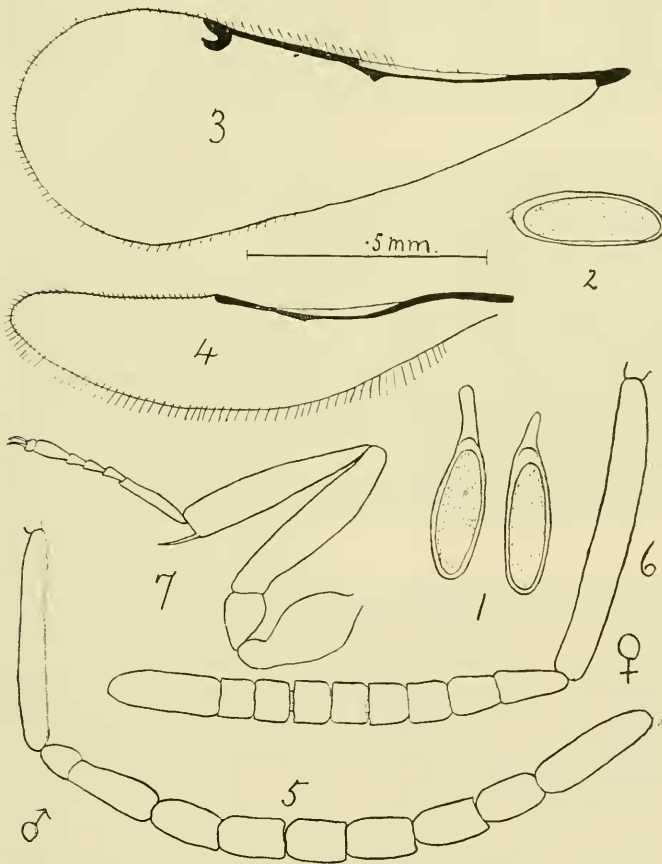
During November and December, 1919, when numbers of *Musca domestica* L., *M. fergusoni* Johnston and Bancroft, *M. vetustissima* Walker, and *M. terræreginæ* Johnston and Bancroft* were being raised in the laboratory at Eidsvold, Burnett River, Queensland, in connection with our work on flies as transmitters of worm parasites of stock, it was noticed that in several batches the percentage of flies emerging was very low, viz., from 15% to 61%. Thus in one experiment with house flies the larvæ pupated on November 21st and a few flies emerged on November 29th and 30th. No more having emerged after the lapse of over a week, the pupæ were collected and counted, when it was found that flies had emerged from only 15 per cent. of them. The remaining pupæ were placed in tubes. On December 15th several small black chalcids averaging about 3 mm. in length were noticed, more emerging during the succeeding days. As they appeared, the little insects were transferred to a large jar the end of which was covered with a piece of cloth, and were fed by smearing honey and water on the cloth. Copulation was observed to occur at once and females readily attacked fresh fly pupæ on the day of emergence.

When about to oviposit, the female walks over the pupæ testing the surface with her long flexible antennæ. A suitable place having been found, the sharp piercing stylet connected with the ovipositor is brought into play and a tiny hole bored in the chitin of the puparium. A few minutes is usually sufficient to effect a puncture, the stylet being thrust for its whole length into the wound.

The eggs are minute oval structures measuring from 0.4 to 0.45 mm. in length by 0.1 mm. in breadth. The shell is minutely papillose except at one end which is drawn

*If Townsend's genera be accepted, then these flies are respectively *Promusca domestica*, *Viviparomusca fergusoni*, *Eumusca vetustissima* and *Promusca terræreginæ*.

out into a blunt projection (fig. 1) varying somewhat in length. This point is not obvious in the uterine egg (fig. 2). The larva on hatching is a tiny white segmented creature which applies its mouth to the surface of the fly pupa and gradually increases in size at the latter's expense. When the chalcid larva pupates, it assumes the form of the adult, the structures being, however, soft and white and surrounded by a clear envelope. During the pupation stage the hard chitinous cuticle of the imago is developed.



Text-figures—camera lucida drawings, all to the same scale.

Spalangia muscidarum: fig. 1, egg from fly pupæ; 2, egg from uterus; 3, 4, fore and hind wing of female; 5, antenna of male; 6, antenna of female; 7, third leg of male.

When the insect is ready to leave the pupa case of its host, it gnaws an irregular hole at the anterior end and crawls out. Nothing is left of the fly pupa by this time but a dark shrivelled mass. Both sexes of the chalcid are capable of flight immediately upon emergence.

The sexes differ (as has been mentioned by Richardson) in the form of the abdomen which is shorter and more spindle-shaped in the male, whereas that of the female has a prominent projecting terminal region; and in the shape of the head, which in front view is seen to be relatively broader and shorter in the male. The antennæ are also unlike, the difference being indicated in our figs. 5 and 6.

As far as our experience goes only one chalcid develops in each parasitised fly pupa, thus from 53 pupa cases of which individual record was kept only 53 chalcids emerged. The size of the perfect insect depends upon the size of the pupa in which it developed. In one instance a pupa was examined two days after oviposition had taken place, six eggs and two small larvæ of the chalcid being found in it. Two *Spalangia* have occasionally been seen ovipositing at the same time in one pupa. The period of time elapsing during summer (December to February) between the laying of the egg and the emergence of the wasp is between three and four weeks (21 and 28 days).

Pinkus (1913) found that in the laboratory in Texas during the winter months the period varied from 79 to 109 days when the average mean temperature was 56° Fahr.; but that in a situation which was considerably warmer the period was shortened to 61 days; while in parasitised puparia kept out of doors during the winter the larvæ developed very slowly and did not emerge, no doubt overwintering in the pupæ.

Our results show that larval development is passed through very rapidly under Queensland summer conditions. This is a factor which renders it particularly valuable as a means for controlling the spread of noxious muscids in this State.

Pupæ of various muscids were collected and examined during the summer in order to ascertain the percentage infection.

Species.	No. examined	No. parasitised	Percentage
<i>M. domestica</i>	76	64	84
<i>M. fergusoni</i>	214	84	39
<i>M. vetustissima</i>	15	11	73
<i>M. ferræreginæ</i>	83	16	73
Total	386	175	45

In addition to these four flies, others were found to be liable to become parasitised and destroyed by *Spalangia*, viz., *Musca hilli* Justn. and Bancr.; *Stomoxys calcitrans*; and certain blowflies (*Pycnosoma rufifacies*, *P. varipes* and *Sarcophaga misera*). We have not yet experimented with other local blowflies (*Lucilia sericata*, *Neopollenia stygia*, *Anastellorhina augur*, *Calliphora* spp. *Sarcophaga* spp., *Ophyra*, etc.), but there can be little doubt but that the parasite is able to attack them as well as local species of *Fannia*, *Pyrellia* and *Pseudopyrellia*.* The fruit fly, *Tephritis tryoni*, did not prove a suitable host in the one experiment carried out by us.

As far as we have been able to ascertain this constitutes the first record of *S. muscidarum* from a locality outside the United States. Froggatt and Froggatt (1917, p. 32-3), gave a brief description and figures of an unidentified parasite obtained from a blowfly (! *Ophyra nigra*). Though the figures do not quite agree with those of our specimens they probably refer to *S. muscidarum*. In 1918 (p. 18) these authors referred to the species having been bred from pupæ of *Musca domestica*, near Hay, N.S.W.

* We have since found that *Spalangia* will parasitise *N. stygia*; *A. Augur*; *Calliphora incisuralis* (so named in Mr. H. Tryon's reports, but Dr. E. W. Ferguson informs us that it is known as *Pycnosoma dux* in Sydney); and the two common species of *Sarcophaga* found in Brisbane, one being apparently *S. frontalis* while the other is a large golden-faced species with an elongate abdomen.

There appear to be three species of *Spalangia* described as parasites of fly pupæ, viz., *S. hirta* Hal (Graham-Smith, 1919, p. 375, fig. 18) and *S. nigra* Boule from Europe: and *S. muscidarum* Richardson from various localities in the United States. *Spalangia* sp. was figured by Hewitt (1914, p. 167).

Howard (1911, p. 89) referred to finding one (*S. muscæ*, MSS. name) parasitising house fly pupæ in Washington D.C. This was not described until 1913 when Richardson named it *S. muscidarum*, his material coming from Massachusetts (*Musca domestica*) and Texas (*Stomoxys calcitrans*).

Bishopp (1913, p. 124) reported that two species of Pteromalidæ parasitised the pupæ of *Stomoxys*, one of them being *S. muscæ* (i.e., *S. muscidarum*). Forty per cent. of the pupæ bred at Dallas, Texas, were found to have been destroyed by these wasps which were capable of killing the pupæ of the house fly and certain other muscids as well.

Pinkus (1913) mentioned that *S. muscidarum* was the commonest parasite of the stable fly at Dallas, Texas, and gave a description of its habits and larval stages. It was stated that the wasp did not discriminate, when given the opportunity to oviposit in the pupæ of various specified muscids.

Girault (1913, p. 332-3) described three species of *Spalangia*, *S. grotiusii*, *S. australiensis*, and *S. virginica* as well as two of *Spalangimorpha*, *Sp. fasciatipennis* and *Sp. frater* (p. 334) all from North Queensland. The three species of *Spalangia* as well as another, *S. parasitica* (also from North Queensland), and *Sp. fasciatipennis* were further described by him in 1915 (pp. 345-6). As far as is known none of these attack flies.

(2) *Nasonia brevicornis* Girault and Sanders.*

This tiny chalcid was described in 1909, the account being supplemented in 1910.† The first record of its occurrence in Australia seems to have been made by

*Reference to the habits of this and other hymenopterous parasites of flies is made by Howard (1911, p. 89-95); Hewitt (1914, p. 167-170); Graham-Smith (1914, p. 242-4).

†Girault, A.A. and Sanders, G.E. The Chalcidoid parasites of the common house or typhoid fly and its allies. *Psyche*, 16, 1909, pp. 119-132; 17, 1910, pp. 9-28.

Girault (1913, p. 307) who found it in Brisbane in October, 1911, and subsequently reported it (1915, p. 316) as having been bred in October, 1913, by Mr. E. Jarvis, from the sheep maggot fly at Longreach and Aramac in Western Queensland. Jarvis (1913, p. 15) gave a brief account of the parasite, but did not identify it.

Froggatt (1914, p. 110) called attention to the presence in New South Wales of these active ant-like wasps (which he then believed belonged to a native species), parasitising certain blowflies, *Calliphora villosa* and *C. oceanicæ* (i.e., *Neopollenia stygia* and *Anastellorhina augur* respectively), as well as the prevalent "sheep maggot fly" *C. rufifacies*. The parasite (evidently a female) was figured and a short account of its habits published. Later in the same year he and McCarthy (1914), reported the chalcid to be *N. brevicornis* which was stated to attack particularly those blowflies which possessed smooth thin-skinned pupæ, *C. villosa*, *C. oceanicæ* and *C. erythrocephala*, only infesting the stoutly-spined pupæ of *C. rufifacies* when the former were not available. A detailed account of the breeding habits was given (see also Froggatt, 1915; Froggatt and Froggatt, 1916, 1917, 1918—also quoted at length by Graham-Smith, 1916, p. 534, 536-7). Figures of both sexes as well as a short account of the breeding habits have been published recently by Graham-Smith (1919, p. 372-4, figs. 14, 15).

The Commonwealth Institute of Science and Industry has been engaged in rearing this chalcid species near Roma, Queensland, and distributing it where desired in order to control the "sheep blowfly" pest.

We have bred out numbers from pupæ forwarded from Roma by Mr. F. H. Taylor. The maximum number obtained by us from any one blowfly pupa was 18. Froggatt and McCarthy (1914, p. 763) reported finding as many as 75 and as few as two, the usual number being between 25 and 36 per pupa. We found that *Nasonia* will parasitise *Musca domestica*, *M. vetustissima*, *M. hilli* and *M. terræ-reginæ* as well as the blowflies already mentioned. We have not yet tested its action regarding other Muscoid flies. Froggatt and Froggatt (1917, p. 29), stated that in their

laboratory experiments the wasp would indiscriminately lay eggs in fly pupæ of any species (presumably muscoid) apparently showing no particular preference.

(3) *Chalcis calliphoræ* Froggatt.

This chalcid was described from the Hay district of New South Wales by Froggatt (1916, p. 506), as a black wasp about the size of a house fly, with reddish-yellow antennæ, oval shining red-brown abdomen and with thickened hind legs. It is a hardy species which breeds readily in captivity, a single insect killing and emerging from each parasitised pupa. The insect attacks the blow-fly (*Calliphora oceanicæ*) while the latter is in the active maggot stage and apparently does not prevent its pupation (See also Froggatt and Froggatt, 1917, pp. 29-31).

(4) *Dirrhinus sarcophagæ* Froggatt.

This rather large chalcid (6 mm. long) which is about the size of a large house fly, has been recently described by Froggatt (1919) as parasitising the pupæ of the "common flesh fly" (*Sarcophaga aurifrons*). It has highly modified hind limbs which are used to enable the wasp to burrow into the loose soil to reach the pupæ lying an inch or more below the surface.

A species *D. biffardi* Silvestri has been used in Hawaii against the fruit fly.

(5) *Pachycrepoideus dubius* Girault and Sanders.

This chalcid parasite belonging to the Pteromalidæ was recorded by Girault (1913, p. 330) as having been caught on windows at Nelson (March and April, 1912), Cooktown (February 1912) and Herberton (December, 1911), North Queensland. It was originally described as a house fly parasite in U.S.A. No doubt it attacks and destroys various flies in Queensland.

Remarks on certain other hymenopterous parasites capable of controlling the spread of flies, and which might be utilised in Australia against "sheep maggot flies."

Graham-Smith in two excellent papers containing his observations on the habits and parasites of common flies in England (1916, 1919), has published interesting information regarding the hymenopterous parasites which attack

fly pupæ or larvæ, ultimately destroying them. The most important as fly controllers seem to be *Alysia manducator*, *Aphæreta cephalotes* Hal. (both belonging to the Braconidæ) and *Melittobia acasta* Walker (Chalcididæ).

Alysia manducator: Graham-Smith's observations (1916, p. 524-531, figs. 12, 13; 1919, p. 376-381, fig. 20), on this relatively large Braconid which is as long as a house fly, show that it is fairly common in England, parasitising as many as 83 per cent. of fly pupæ collected at certain times, being present particularly in those obtained from sheltered situations. "These facts reveal the extraordinary destruction wrought by these parasites and indicate that larvæ feeding in warm and sunny situations are more liable to attack than those living in shady places" (Graham-Smith, 1916, p. 530). The female which lives only a few days in confinement, attacks and oviposits in larger living larvæ, not waiting for them to pupate. In one experiment Graham-Smith (1919, p. 380) found that a female deposited eggs in at least 206 out of 544 larvæ provided: that 80 other larvæ died, possibly due to infection by the insertion of the ovipositor: and that no less than 343 eggs were still contained in the wasp's ovaries. "Under more natural conditions it is likely that she would have infected a greater number, as the ovaries contained at least 549 eggs." This wasp over-winters as a pupa, emerging in the spring. Its habits should make it a very desirable insect for use against sheep maggot flies in Australia.

Aphæreta cephalotes Hal. This is a much smaller Braconid, being only half the length of the preceding wasp (Graham-Smith 1916, p. 531, fig. 15; 1919, pp. 381-2, fig. 21). From each parasitised blowfly pupa a number (7 to 14) of these insects have been bred out. The species appears to prefer sunny situations for oviposition, small larvæ being selected for the purpose. It passes through the winter while within the fly puparium. From the information available it does not seem to be as valuable a fly-controller as the preceding species.

Melittobia acasta Walker. This is a tiny chalcid whose habits are described in an interesting account by Graham-Smith (1916, p. 532-543, figs. 16 and 17; 1919,

p. 360-371, figs. 10-12). There is a very marked sexual dimorphism, the male possessing rudimentary wings and eyes, as well as peculiarly modified antennæ. The female can live in confinement for a long period (33 to 36 days average—95 the maximum noted) and lay up to 300 eggs. The males have a short life and do not leave the puparium in which they were developed.

This remarkable insect also parasitises the larvæ of solitary wasps, as well as the pupæ of the Tachinid fly which itself parasitises the wasps (Malyshev 1913, *vide* Graham-Smith 1919, p. 371). It is thus both a parasite and a hyperparasite. Howard and Fiske (1912) whose remarks are quoted by Graham-Smith (1919, p. 368, 370), found it attacking several kinds of fly puparia (including Tachinids) and hymenopterous cocoons. Graham-Smith (1916, p. 533) reported that it was not only a parasite of fly pupæ, but acted as a hyperparasite towards the above mentioned Braconid *Alysia*. *M. acasta* is "capable of causing an immense amount of destruction. If it is usually a hyperparasite on the braconid larvæ it is not an insect to be encouraged, since it kills off large numbers of parasites very destructive to flies; if, on the other hand, it usually attacks fly pupæ during the summer months it is most beneficial, its powers of destruction being so great; if, lastly, both braconid and fly larvæ are commonly parasitised, its beneficial action is somewhat neutralised."

In view of the above statement by such an authority as Graham-Smith, and in view of the fact that it is capable of parasitising Tachinid flies and solitary wasps which may be of considerable economic importance in controlling various insect pests, it would probably be unwise to introduce into Australia such a form as *M. acasta* as an agent for controlling the spread of flies.

Dibrachys curvus, another chalcid, seems to be of value as a parasite of fly pupæ, but little information is available to us regarding it (Graham-Smith 1919, p. 371-2, Fig. 13).

None of the foregoing insects were bred out by Mellor (1919) during his work on the habits of various English flies.

SUMMARY.

1. There exist in Eastern Australia at least five hymenopterous parasites which destroy flies (including sheep maggot flies) namely, *Spalangia muscidarum*; *Nasonia brevicornis*; *Chalcis calliphoræ*; *Dirrhinus sarcophagæ*; and *Pachyocrepoides dubius*.

2. Of the various hymenopterous parasites known elsewhere as destroying fly pupæ, three others appear to be of outstanding importance, viz. *Alysia manducator*, *Aphærecta cephalotes* and *Melittobia acasta*. The last named acts also as a hyperparasite of many useful insects (including *A. manducator* and Tachinids) and should not, in the light of our present knowledge, be introduced into Australia. The other two could apparently be safely introduced if desired to assist those parasites already present. The first named seems to be especially valuable in this connection.

LITERATURE CITED

- 1913 BISHOPP, F. C. The stable fly (*Stomoxys calcitrans*) an important live stock pest. Jour. Econ. Ent. 6, 1913, p. 112-126.
- 1914 FROGGATT, W. W. The sheep maggot fly and its parasite. Agric. Gaz. N.S.W., 25, 1914, pp. 107-113.
- 1914 FROGGATT, W. W. and MCCARTHY, T. The parasite of the sheep maggot fly (*Nasonia brevicornis*) Agric. Gaz. N.S.W. 25, 1914, pp. 759-764.
- 1915 FROGGATT, W. W. Sheep maggot flies, Farmers' Bulletin 95, Dept. Agric. N.S.W. 1915 (chalcid wasp parasite 30-37).
- 1916 FROGGATT, W. W. A new parasite on sheep maggot flies. Notes and description of a chalcid parasite (*Chalcis calliphoræ*) Agric. Gaz. 27, 1916, p. 505-6.
- 1916 FROGGATT, W. W. and FROGGATT, J. L. Sheep maggot flies No. 2. Farmers' Bull. 110, Dept. Agr. N.S.W.
- 1917 FROGGATT, W. W. and FROGGATT, J. L. Sheep maggot flies No. 3. Farmers' Bull. 113, 37 pp.
- 1918 FROGGATT, W. W. and FROGGATT, J. L. Sheep maggot flies No. 4. Farmers' Bull. 122, 24 pp.
- 1919 FROGGATT, W. W. The digger chalcid parasite (*Dirrhinus sarcophagæ* n.sp. on *Sarcophaga aurifrons*) Agric. Gaz. N.S.W., 30, pp. 853-5.

- 1913 GIRAULT, A. A. Australian Hymenoptera Chalcidoidea (Pteromalidæ) Mem. Q'land Museum, 2, pp. 303-334.
- 1915 GIRAULT, A. A. Australian Hymenoptera Chalcidoidea (Pteromalidæ) Supplement l.c., 3, pp. 313-346.
- 1914 GRAHAM-SMITH, G. S. Flies in relation to disease. Non-blood-sucking flies. Camb. Univ. Press.
- 1916 GRAHAM-SMITH, G. S. Observations on the habits and parasites of common flies. Parasitol., 8, 1916, pp. 440-540 (parasites pp. 523-537).
- 1919 GRAHAM-SMITH, G. S. Further Observations on the habits, etc. l.c., 11, 1919, pp. 347-384 (parasites pp. 355-384).
- 1914 HEWITT, C. G. The house fly. Camb. Univ. Press.
- 1911 HOWARD, L. O. The house fly. Disease carrier. New York.
- 1913 JARVIS, E. Report of Entomologist on Investigations into the Sheep Maggot pest. (Reports by A. H. Cory and E. Jarvis. Gov. Printer, Brisbane, 16 pp.—Jarvis' report pp. 8-16).
- 1919 MELLOR, J. E. Observations on the habits of certain flies, especially those breeding in manure. Ann. App. Biol. 6, (1), pp. 53-58.
- 1913 PINKUS, H. The life history and habits of *Spalangia muscidarum* Richardson, a parasite of the stable fly. Psyche, 20 (5), 1913, p. 148-158.
- 1913 RICHARDSON, C. H. An undescribed hymenopterous parasite of the house fly. Psyche, 20, (1), pp. 38-9.
- 1913a RICHARDSON, C. H. Studies on the habits and development of a hymenopterous parasite, *Spalangia muscidarum* Richardson. Jour. Morphol., 24, pp. 513-557 (not available).
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